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Vo. XII. Part III. September, 1939.

THE

TEA QUARTERLY

THE JOURNAL

OF THE

TEA RESEARCH INSTITUTE

OF CEYLON

Edited by

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St. Coombs, Talawakelle.

PRINTERS H. W. CAVE & CO., COLOMBO.

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NOTE.

The Laboratories of the Institute are situated at St. Coombs Estate, Talawakelle, and letters and enquiries should be addressed to the Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle. Telegraphic Address :—Research, Talawakelle; Telephone, Talawakelle 44 (Private Exchange). It is particularly requested that letters should not be addressed to officers by name.

EDITORIAL

THE WAR

As with other institutions and businesses, the outbreak of war and consequent calling up of staff for military service will necessarily cause considerable dislocation in the work of the Tea Research Institute. Steps have, however, been taken to ensure that such disorganisation shall be reduced to the minimum, allowing for the fact that only three senior officers are now available of the normal staff of seven.

A careful review has been made of the programme of work in each section, and while it is inevitable that certain investigations will have to be suspended for the time being, it is hoped that the more important lines of work, and particularly long term field experiments, will continue without interruption.

Temporarily it is to be anticipated there will be a considerable falling-off in the number of enquiries received by the Institute owing to the absence of so many Estate Superintendents on military duty. War conditions will, however, raise new problems grouped under the general consideration of how best to maintain fertility and quality.

Though stocks of fertilisers at present held in Ceylon are believed to be above normal, should the war be protracted certain constituents of the usual mixtures are likely to become scarce and expensive. In these circumstances changes in present cultivation programmes will be inevitable and consideration of the problems likely to arise should not be unduly delayed.

CLIVEMEARE TEAS

In the Annual Report for 1938, Bulletin No. 18, an account was given of the work carried out on the "Clivemeare" process of manufacture. A further invoice of such tea made during the flavoury season has been sold in London together with an invoice of normal manufacture made at the same time. Details of these invoices are given in this issue from which it will be seen that the Clivemeare tea obtained a substantial premium over the control on account of the excellent liquors and infusions.

In view of the encouraging results obtained it was decided to give this process a more extended trial and to send six further invoices to London. Two of these were despatched but had not yet been sold at the outbreak of war. Owing to the fact that Government has taken over control of the London market it is obvious that no information will be gained as to the relative merits of such invoices by future London sales. In these circumstances the experiment has been suspended for the time being.

LOSS OF NITROGEN FROM FERTILISER MIXTURES

In *The Tropical Agriculturist*, Vol. XCII, page 220, figures were quoted indicating that losses of nitrogen of a serious nature might occur during the storage of fertiliser mixtures containing saphos mineral phosphate, ammonium sulphate and muriate of potash.

These results being at variance with previous findings by the Tea Research Institute, steps were taken for a more systematic examination of the position, the work being carried out jointly by the Tea Research Institute and the Coconut Research Scheme. A preliminary report of this investigation is given in the present number and it is satisfactory to be able to state that the results obtained show that there is no reason to fear any appreciable loss of nitrogen when such fertiliser mixtures are stored under reasonable conditions. This finding is of considerable importance in view of the fact that mixtures of the kind in question are widely used on estates.

PHLOEM NECROSIS

Plates illustrating typical *Phloem necrosis* symptoms, and suitable for issue to estate staff to assist in the identification of the disease, are now available and can be supplied at a cost of three cents per copy plus postage.

VISITOR'S DAYS

Visitors are asked to note that the second and last Wednesdays in each month have now been set aside as Visitor's Days. Visitors can be seen at other times but are asked in this case to make an appointment if possible.

SENDINC IN OF SPECIMENS

Specimens of bushes, etc. for report sent to the Institute by train should be forwarded to Talawakelle Station C/o. Messrs. M. Y. Hemachandra & Co Carriage should be prepaid.

ROLAND V. NORRIS.

A VIRUS DISEASE OF TEA.*

C. H. GADD, D.Sc.

Phloem necrosis of tea is a virus disease. Its cause is something quite different from that of other tea diseases with which you are acquainted, so it may be necessary to explain in what respects this differs from other, better known diseases of tea, caused by fungi.

What is a virus? Until recently, the most widely held view was that viruses were minute organisms resembling bacteria, but too small to be seen by ordinary microscopic methods. Recent research, however, tends to show that the chemical composition of a virus is somewhat different from that of an organism. That, however, need not concern us here. The simplest conception of a virus is of something so small as to be invisible under an ordinary microscope, yet resembling a living organism in its power of multiplication.

Apart from its size, a virus differs from most other plant pathogens (disease-causing organisms) by its obligate parasitism. An obligate parasite is one which will grow only in living tissues; growth and multiplication cease when it is removed from its living host. The well-known parasites of tea such as Poria, Rosellinia, etc. are not obligate parasites. They can live on dead matter, and may be grown quite easily on artificial media in the laboratory. All known viruses are obligate parasites. We may extract a virus from its host plant or animal, but having done that there is no method as yet known, by which that extracted virus can be induced to increase in amount. When, however, it is injected into a suitable living host it increases in amount, very rapidly as a rule. Because of its obligate parasitism a virus rarely kills its host plant. Its own survival depends upon the existence of the species of plants in which it can live. Some viruses kill a few species, but such viruses always have alternative hosts in which they cause little or no disease.

At the Tea Research Institute Conference in February I commented on the fact that *Phloem necrosis* rarely, if ever, killed a tea bush and said that that was one of its worst characteristics. Dead bushes attract far more attention than sickly ones; there is always a hope that the latter will get better after manuring or pruning, but a dead one has to be dug out.

* An address given to the Dimbula, Nuwara Eliya and Dickoya District Planters' Associations on May 29th, June 17th and June 19th, respectively.

Another consequence of obligate parasitism is that when such diseased plants are uprooted and destroyed, no infective material is left in the soil. No advantage is to be gained, therefore, by leaving a site fallow for a period. Supplies may be put in immediately without risk of infection from the soil.

We are accustomed to speak of leaf diseases, stem diseases and root diseases, and those terms are useful in that they indicate the seat of the disease. A leaf disease, as a rule, attacks the leaf only and does not pass into the stem or root. One of nature's ways of dealing with such a disease is to shed the diseased leaves. By so doing the plant may be freed from that particular disease for the time being, at any rate. Its freedom will perhaps be temporary, but if the disease recurs on the new leaves it is usually the result of new infection from outside, not from within the bush. Similarly we may get rid of a stem, or even a root disease, if only we could get at it in time, by removing the infected part. With virus diseases it is more usual for the virus to invade the whole plant with the exception of the seeds, and for that reason the disease is said to be systemic. Plants occasionally localise virus infection but, as a general rule, virus diseases are systemic. Consequently, symptoms become more generally and more uniformly scattered over virus-infected plants than they do with fungal and bacterial infections, which are normally localised in leaf, stem or root.

Phloem necrosis in tea follows the general rule of viruses in that infection is systemic; it affects the whole plant with the probable exception of the seed. Symptoms are found in root, stem and leaf; consequently, it is impossible to get rid of the disease by stripping off the leaves or pruning out the stems. The affected bush would survive such operations in most cases, but the new parts when formed would still be diseased, not as a result of new infection but directly from the parts left after pruning. The only way to get rid of all diseased parts is to dig out the bush entirely.

A natural sequel to the ability of viruses to spread through the vegetative organs of plants is that such diseases can be transmitted by grafting. Transmission in this way has become a test whether a plant disease shall be classified as a virus disease or not when a visible parasite is absent. Fortunately, tea is propagated from seed and not by grafting, so the risk of planting out diseased nursery stock is materially diminished.

Plant viruses do not produce spores to be dispersed by the wind like fungi do. Their distribution is brought about by insects. The particular insect concerned is known for many virus diseases, but not for all. It is probable that many virus diseases which are known

to be transmitted only by grafting or by mechanical inoculation do have insect vectors. The insects concerned are usually those which feed by sucking rather than by biting. As regards *Phloem necrosis*, we know nothing of the way it is transmitted naturally in the field. We know that it has spread extensively through the tea areas above 4,000 feet and that it is still being transmitted. It is highly probable, in fact one might say practically certain, that an insect is concerned, but as yet we have no clue to its identity. It is not necessarily an insect which may always be found in tea, but it is one which can and does feed on tea at times.

As regards the treatment of *Phloem necrosis*, I have on several occasions stated that the disease is incurable, and consequently have come in for a certain amount of criticism. Unfortunately, in some quarters, my opinion has given rise to the view that if the disease is incurable there is no reason to bother about it at all, not even to the extent of ascertaining whether it occurs on particular estates. If anyone interpreted my address at the last Tea Research Institute Conference to mean that this disease is of little or no importance I have been sadly misunderstood. In my opinion, *Phloem necrosis* is the most important disease of tea yet recorded, and judging from the damage done by other virus diseases to other permanent crops, this one should be regarded for the time being at any rate, as potentially as great a menace to tea as the coffee leaf disease proved to be for coffee in Ceylon towards the end of the last century. I should not be sorry to have my opinion proved to be wrong, but I should be extremely sorry if any statement of mine gave rise to indifference amongst even a small part of the planting community regarding the incidence and control of this disease. I do not ask that my opinion be accepted as gospel by anybody, but I hope it will not be disregarded merely because it may sound pessimistic.

Where disease is concerned, we are apt to argue from what is known more intimately concerning disease in ourselves and domestic animals, to what may be expected to occur in plants, and thereby often arrive at wrong conclusions. When we acquire an infectious disease we look forward to a normal recovery and restoration to health without the intervention of a surgical operation. A child gets measles. He exhibits all the symptoms; the disease runs its course and in 14 days or so the child recovers his normal health. To achieve that cure, the doctor has directed his skill towards relieving the discomfort, avoiding complications and giving general aid, but the real cure was achieved by the child himself, by what might be termed the anti-microbial properties of his blood. With the cure completed, the child is somewhat different from what he was previously; he has acquired immunity from further attacks of measles, which, by the

way, is a virus disease. Measles is quite typical of so many diseases which run a definite course, and the prime factor in the cure of them is what I have termed the anti-microbial property of the blood. Very few diseases can be cured directly by drugs — malaria is an outstanding example.

A plant has nothing equivalent to the anti-microbial properties of the blood of animals. At best, the plant can limit the invasion of the parasite to a localised area, but as a rule, to get rid of a disease the plant must get rid of the attacked organ. That is relatively simple when leaves are concerned; the leaves may be dropped prematurely as occurs when rubber is attacked by Oidium, Grevillea by Phyllosticta and when a severe attack of Cercosporella occurs on tea. New leaves formed later have no immunity against further attack by the same disease. Diseased stems and roots cannot be got rid of by the plant itself, consequently such diseases often prove fatal. Surgical operations may remove the diseased limbs and so save the lives of the infected plants. A parallel in the animal world is the amputation of a limb because of some incurable disease in it, but with animals and humans, surgical operations are last resources. An animal cannot grow a new limb whereas a plant can. So animals have anti-microbic properties of their blood, and plants, an ability to regenerate parts, but there can be little doubt as to which is the more efficient in dealing with disease organisms.

Perhaps this explanation will make it clear, what I mean by the statement that *Phloem necrosis* is incurable. As already stated, the virus is systemic, affecting all parts, so, parts containing the disease cannot be removed without removing the whole bush. The bush has no internal organisation for destroying the invading virus; otherwise, the bushes would recover without our interference. How then may the affected bushes be cured? A little more or less manure cannot help, and no virus disease of plants has yet been cured by spraying or by injecting chemicals. In the light of our present knowledge of virus diseases in general, *Phloem necrosis* of tea is incurable.

But because the disease is incurable, it does not follow that the disease cannot be controlled. The problem of control is clearly one of preventing infection. This could be achieved by eliminating all sources of infection, by exterminating the insect vector, or by preventing it from feeding on tea. As we do not know the identity of the insect concerned, we cannot start upon its extermination, nor can we take any necessary steps towards preventing it from feeding on tea. So we are left with the elimination of all sources of infection and that, I may say, has proved the most efficient method of control of other virus diseases.

The elimination of all sources of infection means the destruction of all bushes immediately they become infected. That may sound simple, but to put it into effect would mean the uprooting of a gigantic number of bushes, the majority of which are still productive. The disease is not restricted to a few districts as we believed to be the case at first. We have records now of the disease on 51 estates. Many of the records obtained since the conference are from estates in one agency, but I do not believe that that agency has anything like a monopoly of the disease. The distribution of the known infected estates suggests that every estate over 4,000 feet is suspect of harbouring the disease to a greater or less extent. When I add to this a statement that some fields have about 50 per cent of the bushes already infected you may form some idea of the number of bushes involved.

The question arises whether it is essential to remove all those bushes immediately. To that I would answer 'No,' which I hope will show that I am not entirely pessimistic. It may become necessary later, but at present I do not think it absolutely essential immediately.

We know of non-productive bushes which are necrotic but for every one such bush we can find many others apparently bearing well, yet exhibiting some symptom or other of the disease. One is apt to assume that the latter have acquired the disease recently and that they all will ultimately become non-productive. No matter how plausible such an assumption may appear, it is nevertheless assumption. Undoubtedly some bushes deteriorate rapidly after infection, but I am not so sure that they all do so. We know that some bushes are severely affected by the disease; we have seen cases where every vein of the leaf is discoloured and swollen. Such bushes are invariably poor ones though sometimes of fairly high jât. Other bushes show only slight symptoms and appear to remain productive. Whether they will continue to remain productive time alone will show, but there is considerable evidence that different bushes react differently to this disease.

That however, is not altogether unexpected. Tea bushes in up-country fields are anything but uniform in type; there is not one variety but many. A crop which is propagated vegetatively, like the potato, is much more uniform. As you know, potato varieties are numerous but an expert can name each accurately on inspection. Moreover, it is usual to grow the varieties separately, and it is possible to cultivate a large area with one variety only. The potato is attacked by many virus diseases, most of them have been studied in considerable detail and it is now known that some varieties are very susceptible to one virus, whereas others when infected by the

same virus show only mild symptoms or no sympton at all. The same variation of reaction by different varieties probably occurs in tea, and if so, that fact would offer the best means of control, in that the effects of the disease could be avoided by growing resistant varieties.

Control measures of that type may be easy for the potato grower, but it is quite a different matter with tea. By a variety of tea I mean something more than jât. The terms, High, Medium, Low, Indigenous, Hybrid, China and other jâts all include numerous varieties. Tea varieties have not been defined and it seems unlikely that they will be in the near future. Moreover, it is unlikely that in the near future we shall see pure seed, *i.e.*, seed which will give rise to anything approximating 100 per cent plants of exactly one type, alike in all characters. Obviously it is almost impossible at the present time to supply vacancies with one variety, and that, resistant to *Phloem necrosis*.

Before leaving these generalities, there is another point I would like to mention. The study of certain diseases has shown that there are several varieties of particular viruses. One variety may be very virulent and cause severe symptoms whereas another variety of the same virus may produce mild symptoms only and cause little damage. If different varieties of the *Phloem necrosis* virus occur, their effects in the field would be similar to those I have already ascribed to variation in resistance of different bushes, *i.e.*, some bushes would show mild and others severe symptoms. Since both variation in the virus and variation in resistance of bushes are possible, even probable, it will not be an easy matter to determine whether a bush showing mild symptoms has been infected by a mild variety or whether the bush itself has a high resistance to a virulent variety.

I have spoken about possibilities and probabilities far in advance of what research on this disease itself would warrant. I have briefly outlined them to show that although the disease may be incurable it may yet be controlled.

The recommendations I make at present are that non-productive bushes should be removed early. That recommendation should need no explanation on economic grounds. From the pathologic viewpoint it is apparent that such bushes are not resistant. There is, however, the other possibility that such bushes are infected by a virulent form of the virus. If so, then it is equally obvious that the sooner that infectious material is out of the way the better.

The sites of bushes removed because of this disease may be supplied immediately. I am sometimes asked what is the use of

Fig. 2

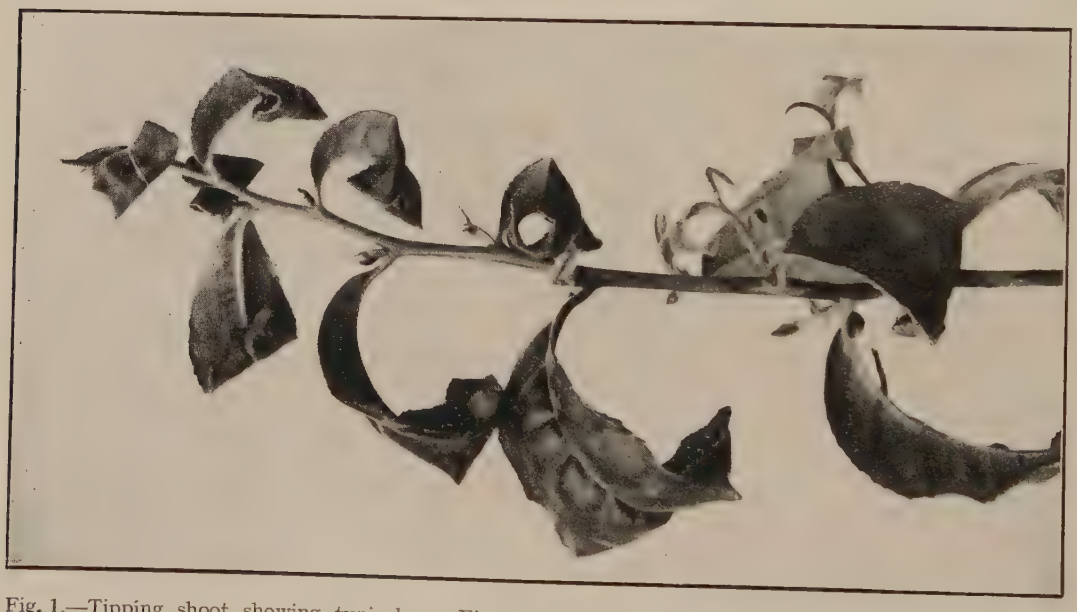

Fig. 1

Fig. 1.—Tipping shoot showing typical curled leaves.

Fig. 2.—A zig-zag branch from a necrotic bush. All infected bushes do not display this type of branching; but when it occurs the bush is usually necrotic.

supplying if the young plants are liable to the disease. To that I would reply that a dog breeder who loses a few pups from distemper does not stop breeding because future litters are liable to distemper, nor does he await the distemper immune breed. If tea plants vary in their resistance to this disease some of the supplies are sure to be more resistant than the bushes which have been removed because of their susceptibility.

Whether such measures will be sufficient to control the disease remains to be seen. They may have to be altered considerably later when more is known about the disease. They may prove sufficient on some estates but not on others, depending upon their elevation, probably.

All that is asked at present is that Estate Superintendents should keep a lookout for this disease; if found, to report that fact to the Institute; and to remove the uneconomic bushes. The only symptom that need be looked for at first is the backward curl or arch of leaves such as is exhibited by the specimens shown. (Figs. 1 and 2). Acquaintance with that symptom usually leads to the recognition of milder cases. The Mycological Division will willingly examine specimens for verification.

The best advice that could be given from a pathological point of view would be to remove every known infected bush, but I fear that on many estates such a recommendation is not economically practicable. Where the number of affected bushes is relatively small and the cost not prohibitive, I think it should be done. In any case, the non-productive bushes should come out early. Records of these removals will, in the course of time, show to what extent the disease is being controlled and what need there may be for more drastic measures. They would show whether infected bushes which are left at one round of removals because they are still economic producers, do in fact become worse and non-productive, and have to be removed at a later round. Information of that type is obviously of value and will assist in getting a better understanding of the disease.

DISCUSSION.

(In order to avoid repetition and to bring related questions together the discussions at the three meetings have been amalgamated).

Mr. G. K. Newton (Dimbula) said that the Chairman had asked him to open the discussion on *Phloem necrosis* mainly because he had been responsible for first finding the disease in that district.

Dr. Gadd in his address had mentioned that *Phloem necrosis* rarely killed the tea bush and that that was one of the worst characteristics of the disease. In 1937 he (Mr. Newton) had found a dead tea bush on which he could recognise no disease so he sent it to St. Coombs, where the death was attributed to *Phloem necrosis*. Had that bush not died, it would not have attracted his attention and might not have been dug out for examination although it might have looked sickly. After the Institute had given details as to how the disease could be recognised he had found other necrotic bushes. He endorsed Dr. Gadd's opinion that sickly bushes did not always attract attention; and for that reason he thought it safe to assume that *Phloem necrosis* had existed in Ceylon tea for years without their knowledge.

Another characteristic which he considered dangerous was the slowness of its action, relative to crop returns. From a necrotic field of tea in that district the yields over four pruning cycles had been:—

1926/29 — 1,547 lbs. per acre

1929/32 — 1,570 ,, ,, ,,

1932/35 — 1,634 ,, ,, ,,

1935/38 — 1,866 ,, ,, ,,

Those figures showed an increase of about 100 lbs. per acre per annum due to liberal cultivation. Those figures suggested that nothing was wrong, but the increase in yield for that period over the whole estate amounted to some 200 lbs. per acre. Thus it could be seen that crop returns gave little indication of the disease during its initial stages.

He had been told of a director who came up from Colombo especially to see a field of necrotic tea, and when informed that the field gave an average of 1,000 lbs. per acre, expressed the opinion that his time was being wasted. It would be difficult to hazard a guess how much longer that field would continue to give 1,000 lbs. per acre but he thought they must now assume that there was little doubt of its falling off slowly but surely.

He complimented Dr. Gadd on his discovery that this disease was caused by a virus and he looked forward to the time when he could congratulate him on the discovery of the identity of the insect transmitter.

His own observations suggested that the disease occurred principally in fields exposed to wind and where soil was not particularly good. He asked whether Dr. Gadd considered such observations to be significant.

He had also noticed that the disease occurred chiefly on bushes of comparatively low jât and not on high jât, light leaf bushes. On that question he would like to hear other opinions.

Mr. Newton concluded by saying that now Dr. Gadd had strongly recommended the replacement of unproductive bushes by supplies, he foresaw that the many bushes which had been uneconomic units for years would now receive attention which they had escaped in the past. By the substitution of better jât supplies, they might see in the years to come more even and higher yielding areas in tea up-country than was the case that day.

Mr Byde Martin (Dimbula) said that his observations had been confined largely to tea of good hybrid type together with a certain amount of high jât Manipuri type. He had noted the disease to occur in two ways, in single bushes and in groups. Single bushes were situated amidst perfectly healthy, flourishing bushes growing in good soil. Groups occurred where soil conditions were poor, and in places subject to strong winds. Where the disease occurred in groups the affected bushes did not form a compact block as was usual with Poria but were more loosely scattered. In a block about the size of that room 25 to 30 per cent of the bushes might be found to be affected.

The age of the tea was mostly between 40 and 55 years; it also occurred in some old seed-bearers about 60 years old which had been cut back about 40 years ago and taken into plucking. He had not found the disease in the high jât tea which was about 30 years old.

The disease occurred most markedly on the top of the estate where the south west winds were felt very strongly, and on exposed ridges. The fields most severely affected by *Phloem necrosis* were quite definitely the worst yielders.

In view of Dr. Gadd's opinion that the seed would probably be free from the virus he asked if any experiments had been carried out to verify that view. He also enquired whether *Phloem necrosis* had been identified in other tea growing countries, the Netherlands East Indies or India, and whether the same disease was known to occur in plants other than tea.

Mr N. M. Sanders (Nuwara Eliya) said he had listened to Dr Gadd's most interesting and, from the point of view of the tea

industry, most disturbing address — disturbing perhaps because there were so many unknown factors.

The only cheerful point appeared to be that they might supply a vacancy caused by *Phloem necrosis* without any fear of infection from the soil. Prior to that he had thought it might be necessary to sterilize the soil by allowing it to remain fallow for a considerable period.

He presumed that even if one or two rootlets of the diseased bush, which had been removed, were accidentally left in the soil no possible infection could be transmitted from those to the newly planted supply.

Apart from grafting, the only means of transmitting the disease from one bush to another was by the particular insect vector.

If, as he understood, the disease was continually spreading from diseased to healthy bushes by means of the insect vectors, it would seem that replanting areas, bordered on all sides by old tea, some, perhaps all, of which was infected by *Phloem necrosis* could not be immune from attack for very long. Yet, taking the case of young supplies which, looked at in relative proportion, were exactly similar to replanted areas, it seemed extraordinary that such supplies, even up to ten years of age or more, appeared to exhibit no symptoms of the disease.

That led him to ask whether it was not better policy to replant, say, five acres a year rather than to supply individually the whole estate. In his own case, the cost would be very little extra and the coming into bearing of the replanted area would probably be very much quicker.

He wished to know whether Dr. Gadd could give an explanation of that fact. Could it mean that those insect vectors transmitted the virus at very irregular intervals, governed possibly by climatic conditions? Or was it that young tea was naturally more resistant to such attack?

The statement that *Phloem necrosis* was systemic (except possibly the seed) was, he presumed, an assumption drawn from the fact that it was rare to find a badly infected bush in the reproductive stage. He had with him, however, a few samples which, to a certain extent, belied that, and in consequence he was led to think that in the case of bushes less highly infected, fruiting would continue. It would therefore seem necessary that all recognised sources of tea seed should be subjected to inspection as a precaution against planting out from infected stock.

He wished to know whether *Phloem necrosis* had been discovered on tea areas which had been out of production for a number of years. If that might not be the case, might there be some connection between such tea and supplies, the inference being that tea in plucking was less resistant to the virus as well as indicating the possible method of approach of the disease — *via* the shoots broken by plucking?

With regard to the elimination of the source he wished to ask what steps were being taken to identify the insect vector. Could estate superintendents be of any assistance in that direction? If such insect was identified was it likely that a parasite could be discovered to combat it?

Dr. Gadd said that he thought Mr. Newton's memory to be at fault when he had stated that he (Dr. Gadd) has diagnosed *Phloem necrosis* on a dead bush in 1937, because that disease could not normally be recognised in a dead bush. He too had a Ceylon memory, so he could not recall what the top of the bush looked like, but he was certain that the roots were alive. Otherwise the presence of dead cells in the phloem would have been meaningless. So Mr. Newton evidently took more interest in sickly bushes than he pretended. He thought, however, there would be general agreement on the fact that dead bushes attracted more attention than did a larger number of sickly ones, particularly if the sick bushes were not together in a compact block.

He agreed that crop returns gave little indication of this disease in its initial stages, and judging from some figures that were given at the Tea Research Institute Conference in February, it appeared that in some instances, advanced stages of the disease might not be reflected markedly in the crop. In contradistinction, he recalled that before much was known of *Phloem necrosis* he was asked to examine a field to ascertain, if possible, the cause of its steady but marked fall in yield. After investigation he had no doubt that the real cause of that fall in yield was the disease *Phloem necrosis*.

It was a fairly common experience on estates where badly necrotic bushes had been taken out in large numbers, that the immediate effect on yield was negligible. It was to be expected that as more bushes became unproductive and were removed for that cause, there would be a diminution of crop harvested. He understood that such falls were occurring in some fields.

To illustrate the fact that the removal of non-productive bushes would not depress the yield he stated that he had been told by an estate manager of a field from which 5 per cent of the bushes

had been removed, not because they were necrotic but because they were considered uneconomic. During the next cycle the yield from that field had increased.

It would be apparent that the effect of that disease could be masked, at least for the time being, by liberal cultivation. How long the effects could be so masked he did not know, but he thought it would be inadvisable to accept the view of the director Mr. Newton had referred to, and to think all was well so long as the crop yield was satisfactory.

Dr. Gadd said that he had not personally noticed that the disease occurred principally in wind-swept fields nor where the soil was not particularly good. The significance of the observations would depend upon the extent of their applicability to all places where the disease occurred The observations might be correct when limited to a small area but their value would decrease if they were not equally correct when applied to the larger area. He felt disinclined to generalise the soil observation, because the disease occurred very widely in the Kandapola area and he was not prepared to agree that the soil in that district was not particularly good, especially when compared with soils from other districts where the disease was not known.

Mr E. G. Groves (Chairman, Dickoya Planters' Association) enquired whether Dr. Gadd had arrived at any conclusions regarding the effect of wind on the distribution of the disease.

Dr. Gadd replied that he personally had not been able to determine any connection between wind and the distribution of *Phloem necrosis*. If the insect vector were carried mainly by the wind the disease would probably follow a course defined by the direction of the prevalent winds. But so far he had no evidence to warrant any such conclusion.

Concerning the mode of occurrence, Dr. Gadd agreed with Mr. Byde Martin that although the disease was best known in patches such as he had described, it also occurred more or less as single bushes surrounded by healthy tea. Recently he had attempted to survey a rather lightly affected field by examining every bush in certain rows and noting the number healthy and diseased. There might be 20 or 30 healthy bushes in a row, the next one or two might show symptoms of the disease, and the row then continue as healthy bushes. Where diseased bushes were found in those circumstances it was often possible to find other bushes nearby in adjacent rows. He feared that the apparent single bush cases were really the beginnings of patches, but prolonged observation was necessary to be sure of that.

Dr. Gadd said that he had found no record of *Phloem necrosis* of tea in places outside Ceylon but intended making further enquiries on that point. Also, he knew of no plant other than tea which carried the specific virus concerned in that disease. Such plants might exist, but if so, he did not know what they were.

Mr. Hugh Gordon (Dickoya) asked if Dr. Gadd could say how long *Phloem necrosis* had existed in the Island.

Dr. Gadd replied that he had no idea. He had first become acquainted with the condition about 1935 and the disease was well established then. He knew of one affected field which the Superintendent said had been in the same condition for the last 25 years, but when pressed, could not remember whether the bushes exhibited curled leaf or whether the field had so many unproductive bushes when he first knew it. In the absence of written record it would be extremely difficult to estimate how long this disease had occurred in Ceylon.

Mr. Watkins Baker (Dickoya) said that he understood Dr. Gadd to say that the lowest elevation at which the disease was found was 4,000 feet. Was it likely, and would it surprise him to find it at sea level?

Dr. Gadd said that that was a difficult question to answer. The lowest elevation at which the disease had been recognised was about 3,400 feet but with that exception the estates known to have this disease were situated above 4,000 feet. It seemed to him that the nearer he worked to the 4,000 feet mark the more difficult it was to recognise the disease. Was it that the symptoms developed better at higher elevations and so enabled the disease to be more easily recognised? That, to his mind, raised the important question whether temperature had an important bearing on this disease. The bush might have the virus within it, yet because the temperature was such, the symptoms did not develop. It was known that plants could be infected by a virus and yet show no symptom. In that respect they were like enteric carriers, persons who enjoy normal health, yet have the misfortune to infect their neighbours with enteric.

He referred to a virus disease of passion-fruit in Queensland. Symptoms of that disease were most readily detected in spring. Owing to the increased temperature of summer the symptoms then became masked, but the plants produced a worthless crop of woody fruit in the winter. He had no evidence that temperature had a similar masking effect with the virus of tea, but if that possibility were taken into account the virus may occur at lower elevations than was then suspected.

Another possibility was that the insect vector occurred only in up-country districts. In that case the range of the disease would coincide with the distribution of the insect. In the absence of conclusive evidence and until such time as the facts could be determined, those arguments were not worth pursuing. The experience of the Institute was that the symptoms of the disease did not appear much below 4,000 feet.

Mr. M. L. Wilkins (Dickoya) asked whether the examination of specimens with a microscope would help superintendents to identify the disease more easily.

Dr. Gadd replied that he did not wish to trouble superintendents with methods of identification of that sort. The only symptom he would ask superintendents to look for first was the backward curl or arch of the leaves. There were of course other symptoms, some of which were difficult to put into words, but if superintendents would, in the first instance, look for the symptom mentioned they would also become acquainted with other characters of affected bushes. In cases of doubt the Institute was always willing to examine and report on specimens.

Mr. C. Owen (Dickoya) suggested that it would be useful if cheap reproductions of photographs depicting the symptoms of the disease could be distributed among the more intelligent of the labour force. They would then be in a position to judge of the existence and extent of infection on estates.

Mr. E. M. Windus (Dickoya) thought they should not be cheap ones. They should have perfect reproductions for the purpose of identifications.

Dr. R. V. Norris promised to go into the question. He thought the cost would not be prohibitive as the principal item was the preparation of blocks and a number of blocks prepared in connection with the recent conference were already in existence. So the actual cost of producing copies would be only that of printing.

Mr. Marsh Smith (Dimbula) enquired whether a badly infected bush could have some leaves not showing the symptoms of *Phloem necrosis*.

Dr. Gadd replied that young, recently formed leaf rarely exhibited the symptoms of the disease though they might develop later as the leaves aged. The leaves produced on a shoot during one rush of growth might exhibit the symptoms markedly in those leaves near the fish leaf, yet the symptoms would not be evident in the younger leaves near the growing point. For that reason it was preferable to send older leaves for examination when there was doubt

regarding infection. Some bushes showed the symptoms clearly on part of the bush only but as a rule badly infected bushes were easy to recognise.

Mr. H. L. Cleghorn (Dimbula) asked whether a necrotic bush became more normal as it became older from pruning.

Dr Gadd replied that the disease was most easily recognised in the fields coming back from pruning, about tipping time. In the second and third years from pruning, fields as a whole looked better, but in his experience bushes which were found to be diseased at tipping could be recognised as diseased throughout the cycle although their general appearance was better in the later part of the cycle. Really bad cases looked as bad in their third year as in their first.

Mr. C. Huntley-Wilkinson (Dimbula) asked if Dr. Gadd would tell them where the phloem tissue occurred in the tea bush and what was its function.

Dr. Gadd then explained the position and function of the phloem. He stated that he had omitted such explanations from his address as he had previously described them in his paper at the Tea Research Institute Conference, published in *The Tea Quarterly*, Vol. XII, Part II, p. 77.

Mr. M. L. Wilkins (Dickoya) asked if there was any truth in the theory that *Phloem necrosis* was peculiar to bad jâts of tea, and conversely, if there was any evidence to support the idea that a good jât was immune.

Dr. Gadd said that the disease occurred most frequently in fields of the hybrid type. He had seen the disease on bushes of good jât also, so he could not say that good jât bushes were immune and poor jât susceptible. It had to be borne in mind that a dwarfing of the leaves frequently accompanied this disease. As high jât was distinguished from low jât principally by the size of the leaf, it followed that necrotic bushes tended to appear lower in jât than they really were. That tended to make the disease mainly one of low jât bushes but undoubtedly the disease did occur on bushes of good jât.

Messrs. A. W. Cantlay (Dimbula) and G. E. D. Foster (Nuwara Eliya) enquired whether it was possible for infection to occur through the use of a pruning knife.

Dr. Gadd replied that it might be possible to transmit the disease with a pruning knife or even by pluckers' fingers as suggested by Mr. Sanders (Nuwara Eliya) because it was the sap of plants which contained the virus, but he did not think it probable. He described an experiment which he had carried out to test that

point. Freshly made pruning cuts were covered with fresh, pulped, necrotic tissues in order to ensure that the cuts were well wetted with juices from infected plants, but so far the treated bushes showed no sign of the disease.

Mr. Gordon Windus (Nuwara Eliya) asked whether infection was conveyed through the leaves or bark, and Mr. Stanley Howard (Nuwara Eliya) whether Tea aphis, which was common in that district, was a probable vector.

Dr. Gadd said that as he did not know what insect carried the disease he did not know whether it was transmitted through the leaf, stem or root. Tea aphis was the first insect to be suspected and he had tried to transmit the disease by means of it. He had been unable to transmit the disease under the conditions he then used.

Replying to Mr. Sanders (Nuwara Eliya), Dr. Gadd said that sucking insects usually became very common during times of drought, so the disease might possibly be transmitted naturally only at such times. He was not prepared to state that was actually the case.

Up to the present very little had been done towards determining the insect vector. He personally regarded that as a job more for the Entomologist than for himself. He realised that the Entomologist might require a good deal of ground cleared for him. For instance, he would want some symptom which developed fairly quickly after infection had occurred. At present, considerable time, a year or more, had to elapse before they could be sure that an experimental plant had acquired the disease.

When the insect had been found he advised them not to bank too much on the possibility of eradicating it. Very few insects, if any, had ever been eradicated by spraying and such like methods, and one could not possibly envisage the spraying of tea at frequent intervals for obvious reasons. They had been very fortunate in finding an effective parasite for tea tortrix, but he warned them not to be too optimistic about finding other parasites to control all their other pests.

Mr. Gordon Windus (Nuwara Eliya) enquired whether it was advisable to burn an infected bush immediately it was uprooted.

Dr. Gadd replied that he thought it unnecessary to do so unless the bush was infected by insects, which was extremely rare. When removed from the ground the bush was not a very favourable food supply for a sucking insect. It was very unlikely that such insects would visit dried up bushes so there was no great objection to such bushes being carried to the factory as fuel. In that respect *Phloem necrosis* was not on par with Poria or Rosellinia.

Mr. E. G. Groves (Chairman, Dickoya Planters' Association) asked whether it was advisable to continue propagation by cuttings in view of *Phloem necrosis*.

Dr. Gadd said that he was asked at Dimbula whether they should stop propagation from cuttings and had answered 'No.' He still thought that answer correct. Estates working on propagation from cuttings first selected their highest yielding bushes. So if the selection had been made in fields where *Phloem necrosis* occurred the chosen bushes would probably be either immune or had escaped infection. It seemed unlikely that diseased bushes would be selected as such bushes would not be high yielders. If truly immune bushes were discovered, vegetative propagation might become the normal method of supplying.

Concerning seed, Dr. Gadd said that Mr. Sanders (Nuwara Eliya) had apparently misunderstood him. When he had stated that it was unlikely that the *Phloem necrosis* virus would be carried in the seed he had not intended to imply that seed production on infected plants was a rarity. He had found very few seeds on necrotic bushes, but then many healthy bushes did not produce seed.

Answering Mr. Byde Martin (Dimbula) on the same subject Dr. Gadd admitted that his statement was a generalisation from what was known of other virus diseases. He had collected and germinated a few seed from necrotic bushes but it was too early yet to decide whether the plants were really free from necrosis.

At Nuwara Eliya, Dr. Gadd also stated that if it were proved later that tea seed did, in fact, carry the virus, it would be very unlikely that infected seed would be recognised by mere inspection, as had been suggested.

Mr. E. M. Windus (Dickoya) asked whether there had been any research regarding the relationship between age of the bush and its susceptibility to the virus. He thought that might have some bearing as to whether it was worth while supplying. In other words was a young plant less immune to the virus than an old one?

Dr. Gadd said that the disease was very rarely found in supplies which had been put out into the field. In one district a large number of necrotic bushes had been removed and so far they had not found the disease in any supply put in their places. But that did not necessarily mean that young plants were immune.

For certain reasons he worked with young plants and had succeeded in definitely transmitting the disease to a two-year-old plant. He believed it possible to transmit the disease even to young seedlings.

He said that immunity to a particular disease was usually an inherent character, so if a plant was immune during the early years of its existence it was likely to prove immune for the rest of its life. Immunity however could not be recognised by mere examination. If a man lived for a time in a malarious district without taking any necessary precautions and yet did not acquire the disease, was that man immune to malaria or had he merely been fortunate in escaping infection? As they knew, it was not every mosquito bite that led to infection. The same would hold good of the transmission of *Phloem necrosis* by an insect vector. The insect would first have to feed on a diseased plant and then on a healthy one before the disease was transmitted, and possibly the virus would have to be left in a particular tissue before infection occurred. Thus it was not possible to distinguish easily between immunity and escape from infection. A plant might grow for some years in a virus area and escape infection but the longer it lived there the greater its risk of acquiring the disease, unless it was really immune.

It would be difficult to determine immunity and its relationship with age until the technique of transmitting this disease was improved and some symptom by which early stages of infection could be recognised. His opinion was that a young plant was as susceptible as an old one.

Replying to Mr. Sanders (Nuwara Eliya), Dr. Gadd said that whether blocks of tea should be uprooted for replanting or whether individual bush sites should be supplied depended upon the circumstances of the case. If only a few necrotic bushes had to be removed it seemed unnecessary to uproot a whole block.

He thought that the policy of supplying should be continued. If, as he had suggested, mature bushes exhibited various degrees of resistance, the same would probably hold good for supplies. As the supplies replaced bushes which had proved to be susceptible, the number of resistant plants in the field would be increased.

He could not offer a very satisfactory explanation of the observation that all supplies up to ten years of age appeared free from this disease although growing in a heavily infected area. It was fairly common to find two bushes next to each other, occasionally growing in the same hole, and one was necrotic and the other healthy. Because of the time an old bush had run risk of infection and yet remained healthy, he had assumed that the healthy bush remained healthy because it was immune or had a high degree of resistance. But he could not assume that all supplies were immune otherwise he would not have been able to transit the disease to a two-year-old plant, as he had done.

He thought that the fact that supplies escaped infection might, in some way be connected with the insect vector. Obviously an older bush formed a larger target for the insect and possibly, the insect preferred to feed on older bushes because of their greater shade or other character.

Mr. P. A. Armstrong (Nuwara Eliya) said that he thought where the diseased area was small relative to the rest of the field the chances of infection would be small if the area was replanted. Was it so when a large number of necrotic bushes were removed while others were left? He thought that supplies put in the places of bushes removed for Poria would have a much better chance of escape than supplies put into a definitely necrotic area because of infected bushes in the vicinity.

Dr. Gadd said that Poria was a fungus which could grow from an infected root for only a short distance through soil in search of another root. Bushes in the immediate vicinity of an infected bush ran the risk of infection. By vicinity, there, was meant within a very few feet of the infected bush. The chances of survival of a supply put into a Poria patch depended upon the distance it was away from the nearest infected root. A few feet usually meant safety. But when they spoke of vicinity of a necrotic bush they did not necessarily mean within a few feet. Much depended upon the flight range of the insect vector. For instance, if the insect normally flew about 50 yards all bushes within a range of 50 yards from an infected bush would be liable to infection. He did not suggest that 50 yards was the actual flight range of the insect concerned, because as he did not know the insect he knew nothing of its habits or movements. Also he could not assess the risks of infection from outside a replanted block as compared with the risks when individual sites were supplied.

Mr. C. M. Durbin (Nuwara Eliya) said it was of vital importance to find out what was the position with regard to the disease as it affected young supplies. He felt that Dr. Gadd has not drawn a convincing picture in his analogy to dog-breeders and distemper. If distemper was absolutely incurable, dog-breeders would soon go out of business. Here was a disease which was incurable. He failed to see what chance they had for their young supplies if they put them out with just a vague chance of their being an immune variety.

He had a field, which Dr. Gadd knew, was heavily infected. It was full of supplies over ten years. Some of them were very big bushes and therefore were more likely to catch the vector's eye than ordinary bushes in plucking. Not one of these supplies over ten years had been infected as far as he was aware. The point

required investigation to find out the reason for their apparent immunity. Unless they could be sure of the economic life of supplies over 30 or 40 years it was a very poor outlook indeed. He thought there was some other reason than those suggested so far as to why supplies over ten years, growing up into big bushes, were still apparently untouched by the disease.

The other point Dr. Gadd had stressed was the importance of eliminating the sources of infection. It appeared to him a counsel of despair. Seeing how very heavily their tea could be affected and they did not even know the early symptoms, it seemed to him, although it might be well to stress the importance of eliminating those bushes, that it was a dark outlook. He wished to see the Tea Research Institute, while emphasising this method of attacking the problem, bringing in the Entomologist to see if something could not be done to find out what the insect was in the case. He also wished to know whether any efforts had been made to get further assistance in investigating the problem.

Dr. Gadd said that he hoped they would understand that he had not come before them with any pretence of knowing all the answers to questions they might put to him. The question regarding supplies was certainly one to which he did not know the correct answer.

He had given a good deal of thought and time to the study of that disease. He had all along painted it as a black picture because he regarded that disease as the worst they knew in tea. Much of the information given by him had been derived from various sources, from research work carried out with other crops and with other viruses. But he had tried as far as was possible to ascertain how far that information held good as regards tea.

As regards the efficacy of supplying, Dr. Gadd said that if he was to be asked whether it was any good going on trying to supply areas, he would ask in return what they would suggest to be done in place of it.

He realised that his answers concerning the apparent freedom of supplies from this disease might not be very satisfactory but he thought that Mr. Durbin's remarks provided another answer. If the early symptoms were unknown it was probable, as Mr. Durbin realised, that many old bushes had acquired the disease and yet showed no recognisable symptom. If he would admit that as regards old bushes would he not allow that the same thing might occur as regards the supplies.

Dr. Gadd admitted that he could not recognise the earliest stages of infection. The disease was recognised from certain gross characters and from the presence of dead cells in certain tissues. He could not envisage those cells being born dead. He knew for a fact that they were not, because they were alive in the youngest leaves of affected bushes. Evidently a period of time elapsed between infecton and recognition that infection had occurred.

To illustrate that point he said that a healthy plant two years old growing in a pot had been inarched to a necrotic bush. The necrotic branch was later severed from the parent below the graft; the pot plant was brought back to St. Coombs, removed from the pot and planted out. Twelve months elapsed before he was absolutely certain that the disease had been transmitted.

The amount of virus which had passed through the organic union of the graft from the diseased scion was immeasurably greater than that which would be injected by an insect during natural transmission. As 12 months passed before the disease was recognised after grafting might not a much longer period have to pass before the disease could be recognised when only a very small quantity of virus was injected by an insect?

That experiment illustrated one of the many difficulties encountered in the study of this disease, namely the recognition of it in the early stages.

Dr. Norris said that it would have been gathered from Dr. Gadd's remarks that one of the most important pieces of work yet to be done in connection with *Phloem necrosis* was to find some means of recognising the earliest possible symptoms of the disease. They felt that the symptoms described were not early symptoms, so the disease might be affecting bushes some time before it could be recognised. That was one of the greatest dangers because it meant that the disease was well in advance and measures to combat it were trailing behind. Early recognition of the disease was obviously desirable. That meant considerable laboratory investigation.

It would interest them to know that the Institute was endeavouring to obtain additional assistance for Dr. Gadd. Enquiries were being made at Cambridge, Rothamsted and the Colonial Office to ascertain if a temporary man — they could not afford a permanent appointment — experienced in that type of work could take up that side of the investigations. There must be some difficulty about it because people with experience of virus diseases were not plentiful, but they were endeavouring to do the best possible.

A DESTRUCTIVE ROOT DISEASE OF TEA CAUSED BY THE NEMATODE *ANGUILLULINA PRATENSIS*.

C. H. GADD, D.Sc.

The object of this paper is to draw attention to a destructive root disease occurring on a few estates in Ceylon. The cause has recently been ascertained to be the eelworm *Anguillulina pratensis* (de Man) Goffart, for which the common name 'Meadow nematode' appears to have been adopted in temperate countries. That name perhaps will not appear very appropriate to tea planters in Ceylon, nor to coffee planters in the Dutch East Indies and South India. It seems preferable, however, to maintain the same common name here than to adopt another which might be equally inappropriate in the U.S.A., England, or elsewhere.

The leaves of affected tea bushes are lighter in colour than is normal, so diseased areas appear somewhat 'yellow.' The bushes are generally unthrifty, deficient in foliage and have a 'thin' appearance (Fig. 1). Below ground, there is a marked absence of feeding roots and the main woody roots are usually dead for some distance from the tip. The main roots are not distorted in any way, nor are such feeding roots as remain swollen or knotted as when attacked by the root-knot nematode, *Heterodera marioni*.

There is no external symptom by which the presence of eelworms in the tea bush can definitely be recognised. It must not be assumed that all bushes with yellowish leaf are attacked by this eelworm, even if the bushes are partially defoliated. Similar above ground symptoms occur from other causes, *e.g.*, when bushes are infested with red spider or mites. When, however, there is a marked deficiency of feeding roots accompanying these above-ground symptoms, the presence of eelworms should be suspected. Nematologists are somewhat sceptical that plant diseases caused by nematodes can be recognised with much accuracy by pathological symptoms alone, and consider an examination with the microscope to be the only safe way to determine the presence of eelworms [13].

Fig. 1. A typical bush infected by *A. pratensis.*

Fig. 2. Eelworms isolated from the tissue (×80).

Fig. 3. Eelworms within a root of *Tephrosia vogelii* (×52).

Fig. 4. An eelworm lying within the tissue of *T. vogelii.* Note the constriction near the middle of the body where it passes through a cell wall (×180).

The eelworms may be found in lesions in the small feeding roots, but a better place to find them is at the junction of healthy and dead cortical tissue of the main roots. These junctions are not usually easily determined by superficial examination, but if the bark is lightly scraped away with a knife, living tissue will be seen to be white or pink whereas dead tissue is brown. The dead tissues are usually at the extremities of the main roots, though sometimes islands of dead tissue are found in the thicker parts of roots. The junction between the living and dead tissue is usually sharply marked, the boundary being quite distinct.

When excavating suspected bushes, care should be taken to dig out the main roots to their extremities. It is unnecessary to send the whole bush to the Institute's laboratories for examination; a few roots are sufficient if the specimens bear living and dead tissues. The specimens should be wrapped in hessian and the parcel secured firmly. They should arrive at the laboratory in as fresh condition as possible to facilitate examination.

Longitudinal sections, when stained in cotton blue in Amman's mounting fluid show the eelworms in abundance at the junction of the living and dead tissues of the root cortex. Few can be found in the dead tissues away from the junction, and none in the live tissues beyond. Evidently the eelworms move slowly but continually through the tissues, killing the cells as they go. The damage they do undoubtedly aids the entry of fungi which hasten decay.

Sometimes the worms may be seen coiled within individual cells but more frequently they lie parallel to the woody axis with their heads directed towards the living tissue. The bodies are often seen to be constricted where they pass through cell walls (Fig. 4). No distinct cavities or passages have been seen, such as are illustrated by Bally and Reydon [1] for Coffee. Movement is through the cells and not between them. Entry is achieved by the worm boring a hole through the cell wall by means of a small but powerful stylet or spear like organ situated in the mouth. More than one eelworm often moves along the same track.

The eelworms also tend to move inwards towards the woody cylinder but they never enter the wood. For this reason they are most easily found by stripping off the cortex at the junction of the living and dead tissues when they may be seen with a low power microscope as short hyaline threads lying on the inner side of the cortex which adjoins the wood. Examined thus, the worms exhibit very little movement and they might well be mistaken as dead. From this position they are easily washed off with a small quantity of water when they can be more closely examined, free from root

tissue (Fig. 2). In such a collection adults, larvae and eggs will be found. Even in water the worms remain very sluggish, all movement being very slow when compared with that of many species found in the soil.

Although the eelworms appear sluggish when examined as above, the following experiments show that they can move when advantage is to be obtained thereby. A piece of cortex from the root of an infected bush bearing numerous eelworms was placed in a damp chamber with the inner side of the cortex upwards. A recently germinated tea seed with a root about 2 inches long was placed so that the tip of the root rested on the cortex near the location of the eelworms. Forty-eight hours afterwards the root was killed, stained and cleared in the manner described by Godfrey [4] and examined. Numerous eelworms were to be seen in the root cortex a short distance behind the tip. They lay curled within the cells or extended parallel with the axis.

The experiment was repeated using the roots of recently germinated seed of *Tephrosia vogelii* and *Crotalaria anagyroides* instead of tea. The roots of both plants were invaded by numerous eelworms, adults as well as larvae. The Tephrosia root was more heavily invaded and a photograph of part of it is reproduced in Figure 3. As in tea, entry was made a short distance behind the root tip, in the piliferous layer. These observations agree with those of Linford [7] who observed *A. pratensis* to group round the roots of plants avoiding the elongating zone and collecting chiefly in the piliferous layer.

Specimens were sent to Dr. T. Goodey of the Institute of Agricultural Parasitology who kindly identified the eelworms as *Anguillulina pratensis* (de Man) Goffart.

Anguillulina pratensis was first described by de Man in 1884 as a rare species living free in the soil under the name *Tylenchus pratensis*, and by Kühn in 1889 as *T. gulosus*. *T. coffeae* was described by Zimmerman [15] as a parasite of coffee roots in the Dutch East Indies in 1898· *T. penetrans*, by Cobb [2] from potatoes, etc., from U.S.A. in 1917; *Aphelenchus neglectus*, by Rensch from wheat, etc. in Germany in 1924; and *T. brachyurus* by Godfrey [4] from pineapple in Hawaii. Goodey [5] gives the above names as synonyms of *Anguillulina pratensis*.

A. pratensis has been fully and accurately described by Cobb [2], Goodey [5] and others; it will be sufficient here to state that the adult eelworms measure from 0.45 mm. to 0.7mm. long by 0.02mm. to 0.03 mm. wide; the eggs are about 0.06 mm. long by 0.02 mm. wide; and the first stage larvae are about 0.22 mm. long by 0.01 mm. wide.

Very little is known of the details of its life-history. Hastings[6] estimates that the life-cycle is completed in 54 to 65 days. In agreement with other observers the writer has seen only one egg at a time in the uterus, and solitary eggs only have been observed in tea cortex. Steiner [13] reports that as many as five eggs have been seen deposited tandem, separated by only a few plant cells. Although eggs are usually laid within the plant tissues, parasitism within roots is not essential for reproduction since gravid females and larvae may be found in soil around roots [14]. Mayne's [11] studies on the hatching of the eggs of this worm showed that they do not hatch when kept in a moist chamber without the presence of liquid water. On the addition of water they were found to hatch quite rapidly.

Goodey [5] gives a list of over 50 known host plants which include *Calopogonium mucunoides*, *Centrosema pubescens*, *Cinnamonum camphora* (camphor), *Coffea arabica*, *C. excelsa* and *C. robusta*, *Dendrocalamus asper* (Bamboo), *Dioscorea* sp. (Yams), *Emilia sonchifolia* (a weed), *Gigantochloa apus* (Bamboo), *Saccharum officinaurm* (Sugar cane), *Vigna sinensis* (Cow pea), *Zea mays* (Maize) and various unspecified grasses.

Since the above mentioned list was published, *A. pratensis* has been recorded on several other plants. It is evident that *A. pratensis* infests a large number of widely different plants, and it should not occasion surprise to find it on many others, including almost any of our crop plants, not yet recorded. This eelworm does not cause severe injury to all plants on which it has been recorded. Cobb [2] states that when this eelworm was found in cotton roots the plants were not suspected of being infested, and that no definite evidence exists that it seriously injures the camphor tree. In general, the effects of attack by *A. pratensis* are to restrict growth and to cause yellowing of the leaves — features which, as Steiner [13] comments, are most often attributed to causes other than nematode infestations.

As yet this eelworm has not been found in Ceylon on any other plant but tea, but it seems highly improbable that it has confined its attention solely to that plant. A careful search will probably reveal its presence on other plants.* No explanation can be offered as to how it got into our tea fields and from where it came.

Though the occurrence of *A. pratensis* may cause little or no damage to some plants, its effect on tea is of serious economic importance as can be ascertained from Table I, in which are given the annual and pruning cycle yields of two fields on different estates.

* Since the above was written specimens of ginger roots from the Department of Agriculture have been found to be infested by *A. pratensis*.

TABLE I

Yields of two fields infested with *Anguillulina pratensis*.

Field A. 9 acres 3-year cycle			Field B. 53 acres 2-year cycle		
Year	Yield lb. per acre		Season	Yield lb. per acre	
1929	838		1928/29	515	1,307
1930	462		1929/30	792	
1931	778	2,047	1930/31	618	1,337
1932	807		1931/32	719	
1933	278		1932/33	301	1,077
1934	947	1,603	1933/34	767	
1935	378		1934/35	295	860
1936	195		1935/36	565	
1937	412	987	1936/37	268	767
1938	380		1937/38	499	

The yields of both fields show a marked and increasing fall in successive cycles beginning with that starting about 1933. That the effect of attack began to be reflected in the yields of both fields at about the same time is to be regarded as coincidence rather than an indication of when infection occurred. To affect the yield of a whole field markedly, the eelworm must be widely distributed through the field at that time, so infection must have occurred some years before 1933.

Reference has already been made to the invasion by eelworms of the main woody roots of the tea bush and the consequent death of the cortical tissue invaded. Such injuries alone would not materially affect a tea bush judging from what is known about other root disease of tea. *Poria hypolateritia*, for instance, attacks the woody

roots, and when treating Poria patches it is common to find tea bushes with the greater part of the root system dead and decayed, while the above-ground portion of the bush gives no indication that anything is amiss.

The main attack of *A. pratensis* is on the feeding roots of tea, and in that respect conforms with what is known concerning it on other plants. The eelworms invade the feeding roots, through the epidermal cells and force their way into and through the cortex. A discoloration of tissues follows shortly after invasion and the cells die. The nematodes then abandon the dead tissues by migrating into the soil or by moving further into the healthy tissues of thicker roots. Those that return to the soil seek other new, young roots which they similarly attack. Thus, there is a flow of nematodes from the killed roots, through the soil to young healthy feeding roots. With the passage of time that stream steadily increases and greater numbers of feeding roots are killed. The feeding efficiency of the root system is diminished and the attacked bush begins to show above-ground symptoms, fails to grow normally, and becomes unthrifty. The position ultimately arrives when the feeding roots are destroyed as fast as they are formed, and the bush becomes moribund.

Attacked coffee plants usually have a 'beard'[8] or 'wig'[1] of thick turgid adventitious roots at the collar occupying the top inch or two of soil. This suggests that the eelworms do not like the surface layer of coffee soils, possibly because that region is liable to dry out in the absence of rain. Similar tufts of roots at the collars of attacked tea bushes are not usual but they have occasionally been found on lateral roots partially exposed on the soil surface. An examination of such roots and adhering soil disclosed the presence of *A. pratensis* there.

Although the eelworm lives, feeds and breeds mainly in the roots it also occurs in the soil in large numbers wherever infected bushes occur. Soil examinations in S. India [9] showed that the greatest concentration of eelworms occurred at a depth of about 9 inches, while below 12 inches the numbers decreased. There was also a great seasonal fluctuation of the population. With the onset of monsoon rains an extremely rapid increase of nematodes of both parasitic and saprophytic types occurred [10]. In dry soil, few could usually be found unless the soil was moistened a short time before examination, when both larvae and adults were obtained.

Mayne [9] suggests that there is an adult resting stage in which these parasitic eelworms survive desiccation in soil. Godfrey [5] is of the opinion, based on his observations on pineapple soils, that *A. pratensis* is more resistant to desiccation than is *Heterodera marioni*.

Hastings [6], however, states that *A. pratensis* is very sensitive to desiccation as no living worms were obtained from infected oat roots which had become dry.

The chief danger of spread of the eelworm lies in soil movement. Labourers working on infected areas, particularly during wet weather, are liable to carry the eelworm in soil, adhering to the foot or agricultural implements, beyond the existing limits of infection. A short cut through infected tea is a similar source of danger. During forking the soil tends to move downhill; for this reason and because the sub-soil drainage is in the same direction the general trend of movement of the eelworm is downhill. During heavy rains soil is washed into the drains and may be carried some distance before it sediments in a silt-pit or at the bottom of a bunded or reverse sloped drain. When the silt-pit or drain is cleaned out, the silt is thrown into the tea, and if parasitic worms are present in the silt, as they often are, that tea is liable to become infected. Even when the eelworm-containing drainage water reaches a stream all danger is not eliminated if the stream is liable to flood. Cases have been observed where tea bushes have become infected by silt deposited by a stream after flooding. The transport of roots from an infected area is another source of danger unless precautions are taken to prevent the loss of some of them and of soil adhering to them on the way.

The importance of preventing further spread cannot be too strongly emphasised. Bally and Reydon [1] concerning the spread of this parasite in the coffee lands of the Dutch East Indies write: "In the earlier stages of the planting of Robusta coffee it was only a matter of smallish 'Nematode patches' on various estates. Now the position is different. Not only are there large areas infected by nematodes, but in some cases whole estates."

When once soil becomes infected, it is a very difficult matter to free it again from this eelworm. The most obvious way is to destroy the eelworms in the soil by means of chemicals or steam. Such methods have proved of great value in treating the soils of glass houses, but no satisfactory method has been found of sterilising large areas of field soils to a depth such as is necessary in tea fields. Nematodes as a class are very resistant to chemicals, and although it is possible to reduce materially the eelworm population of field soils by chemical methods, when the area is clear of all vegetation, it has not proved possible to eradicate completely all the eelworms A reduction in the population of parasitic eelworms may be of great value to agriculturists cultivating a crop plant which will occupy the ground for a short period, as the harvest may be reaped before the parasitic eelworms again become sufficiently numerous to damage the plants seriously. With a permanent crop

like tea, nothing short of complete eradication of the parasitic eelworms can prove entirely satisfactory. If relatively few parasites remain after treatment, they will in the course of time increase in number to such an extent that serious damage will be done to the replanted tea.

Another way of killing the eelworms in the soil is by starvation. This necessitates keeping the soil free from all plants on whose roots the parasites can live. With annual crops this is achieved mainly by the practice of crop rotation. After a susceptible crop has been grown, non-susceptible crops are planted during the next 3 or 4 years. During this interval the parasitic eelworm population is reduced to such an extent that it becomes possible to grow the susceptible plant again with successful results. Rarely, however, are the parasites completely eradicated by rotation.

To starve *A. pratensis* out of infected tea soils the land must be kept clear of all susceptible plants for some years. Although it is possible to supply a list of plants known to be attacked by this eelworm, all plants whose names are not on that list are not necessarily immune or resistant. As already stated very little is known of the host plants of this parasite in Ceylon, so it will be necessary to examine periodically the roots of weeds and other plants which may grow on a starved area, to ensure that none is harbouring the pest. Bare fallow would increase the risk of soil movement by erosion and probably affect adversely the fertility of the soil. How long the areas must be kept clear of susceptible plants is unknown. Bally and Raydon [1] report that ground from which coffee had been uprooted and planted with cocoa was not free from this eelworm after 4 years. Pfaltzer [12] reviewing the methods of control of *A. pratensis* in coffee soils in the Dutch East Indies, however, considers that starving the parasite out of the soils will give the best results.

Fluiter [3] reports that in coffee plantations infested with *A. pratensis* many of the plants are killed but a good percentage seem to remain healthy even though their roots are invaded by the parasite. By selecting these apparently resistant plants and growing them on, even in infested soil, they retain their resistance. No resistant tea plants have yet been found but the possibility of their occurrence must not be overlooked.

In the writer's opinion little can be achieved in infected tea areas by a more liberal manurial policy or by greater attention to cultural methods which promote root growth. Such treatment may mask the detrimental effect of the eelworm for a time, but it is highly improbable that infected bushes can be kept in an economic productive condition by such means.

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A NOTE ON THE LOSS OF AMMONIA FROM FERTILIZER MIXTURES*

In *The Tropical Agriculturist*, Vol. XCII, page 220, one of us (M. L. M. Salgado) reported nitrogen losses of a serious nature on storage of fertilizer mixtures containing saphos mineral phosphate, sulphate of ammonia and muriate of potash. This appeared to be contrary to a reference to the problem made previously in the Annual Report of the Tea Research Institute (Bulletin No. 12) 1934, page 17. As a result of consultation between the Coconut Research Scheme and the Tea Research Institute it was agreed that in order to resolve the apparent difference in opinion, more detailed investigation of possible controlling factors was necessary.

A detailed joint investigation was therefore planned to examine the following points:—

(1) The behaviour of mineral phosphates derived from different sources; since the chemical composition of the original rock is known to vary with its place of origin.

(2) The effect of the state of division of the sulphate of ammonia.

(3) The effect of the addition of a "conditioner" (10 per cent of castor cake) to the mixture.

(4) The effect of varying the proportions of the constituents, with special reference to muriate of potash.

(5) The possible influence of climatic conditions, particularly temperature and humidity.

We were able to obtain locally by the help of local fertilizer distributors adequate consignments of the following mineral phosphates: Saphos A, Saphos B (A and B representing two different shipments of the same mark) Gafsa, Ephos and Egyptian. Sulphate of ammonia is marketed in two forms known as "granular" and "rice crystal."

* Copy of a paper which will appear in the next issue of *The Tropical Agriculturist* and published by courtesy of the Director of Agriculture.

The mixtures upon which we have worked were in two series corresponding respectively to the types used on coconut and tea estates. The actual proportions of the various constituents were as follows:—

	Coconut			Tea		
	Phosphate	S/Amm.	Mur/Pot.	Phosphate	S/Amm.	Mur/Pot.
Normal	4	4	2	4	2	1
High Potash	4	4	4	4	2	2

All possible combinations of the quantities and types above mentioned, eighty in all, have been investigated in 25 lb. lots. In addition we have in collaboration with a commercial firm examined the losses occurring in eight saphos mixtures (coconut series) under ordinary commercial conditions of bagging and storage. The Tea Research Institute prepared, stored and analysed the 40 samples of the tea series, and the Coconut Research Scheme similarly dealt with the 40 samples of the coconut series. The latter station dealt with the sampling of the commercial series, whilst as an additional check the Tea Research Institute duplicated the eight Saphos A samples of the coconut series. All samples were examined for moisture and nitrogen content initially, and after intervals of 9 and 30 days respectively. The commercial samples were in addition examined after 60 and 90 days, and the tea mixtures after 60 and 90 days. Methods of preparation, sampling and analysis were jointly standardised.

The preparation for publication of the considerable amount of data accumulated will of necessity take some time. We feel however that in view of the enquiries that have been received by the two stations since the original note was published (*loc. cit.*), an interim report is desirable, particularly since similar work in the same field by P. A. Keiller appears in the current number of *The Tropical Agriculturist*. By the courtesy of Mr. Keiller we have been able to see a copy of his paper in advance of publication.

It may be said at once that we have found in no case losses comparable with those previously reported; and in fact such losses as we have observed are very similar in magnitude to those recorded

by Mr. Keiller. As typical of the results obtained, the following example shows the average loss found on the eight Saphos A laboratory samples of the coconut series:—

NITROGEN CONTENTS OF STORED MANURE MIXTURES

	On Mixing	After 9 days	After 30 days	Total gain or loss
Nitrogen content (per cent on dry)	7.47	7.50	7.30	−0.17
Moisture content per cent	2.24	4.26	7.92	+5.68

Our observation that the commercial samples picked up much less moisture (per cent) than the 25 lb. samples (an increase of 2.04 per cent as against one of 5.68 per cent) makes it highly probable that the greater loss of nitrogen from the smaller samples of 1 lb. weight used in the original investigation (*loc. cit.*) was due to the more rapid uptake of moisture from the very earliest stages.

It now seems clear that the previous findings reported in *The Tropical Agriculturist* (*loc. cit.*) were based on preliminary results obtained from samples which were too small for practical purposes. This may also apply to the Malayan work referred to previously.

The detailed results of our findings will be published in due course but we can state at this point that, in the light of this more comprehensive investigation, there is no reason to fear appreciable loss of nitrogen from manure mixtures containing mineral phosphate, sulphate of ammonia and muriate of potash, stored under reasonable conditions.

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Coconut Research Scheme.

T. EDEN,
Agricultural Chemist,
Tea Research Institute.

M. L. M. SALGADO,
Soil Chemist,
Coconut Research Scheme.

NITROGEN SUPPLY TO TEA*

(REVIEW)

The Indian Tea Association's Experimental Station at Tocklai, Assam, was started at the turn of the century and during its forty odd years of existence has accumulated a considerable quantity of data on the manuring of tea. Mr. H. R. Cooper, the Senior Chemist who for more than half this time has been associated with Tocklai's work on this aspect of tea culture has recently surveyed the manurial and cultivation experiments, more particularly those relating to the use of nitrogen, and, under the title "Nitrogen Supply to Tea" has published the most informative account of manuring that the tea industry has yet had. The memorandum gives a reasoned exposition of the whole science of manuring amply illustrated by examples from the various experiments carried out over a long period of years.

Mr. Cooper brings to his task not only enthusiasm but deep and wide knowledge of tea culture. His method of presentation is a model for all who have the task of giving current advice on matters about which a good deal, but not everything, is known. He distinguishes most carefully between what is fact and what is theory. Where a fact is established he says the results "indicate clearly." Where the evidence is showing a definite trend but is not complete he is content to say "we think then," etc., and where he steps outside definite experimental evidence, he carefully considers what related experimental data are available as a guide and straightforwardly says "the best guess we can make at the moment is . . ." A good deal of confusion in current ideas and practice would be avoided if, when debating the scientific aspects of tea culture, speakers would indicate and hearers could realise where definitely ascertained fact ends and where attractive speculation begins.

The scope of Mr. Cooper's memorandum is seen from a brief survey of its chapter headings: Nitrogen compounds naturally present in the soil; The use of Manures; Trials of different forms of Nitrogen on Tea; Cattle and Line Manure; Humus Composts and the use of

* "Nitrogen Supply to Tea." H. R. Cooper. Memorandum No. 6. pp. 135.—Indian Tea Association, Tocklai Experimental Station.

Waste Materials; The use of Leguminous Plants; Results to be expected from Manuring; Relation of Manuring to other Field Operations; Application of Manure; Soil Erosion. Besides various tables in the text there is a 32-page appendix giving results of experiments and explanatory matter.

For Ceylon readers, the most that can be done in a short article is to draw attention to various aspects of the Tocklai work that correspond with or are complementary to work done at the Tea Research Institute. There are matters in which local circumstances and practices have a preponderating effect in deciding the result. When, as in so many experiments independently planned and carried out by the stations, the same conclusions are reached, the agreement has a very high evidential value. Readers should refer to the original for details, but the following comparisons are of interest:—

Efficiency of Manures.—At Tocklai the experiments show "with any type of manure, the increase in crop is proportional to the quantity of manure up to fairly high limits." (Page 73). This is in accord with our findings which Mr. Cooper quotes. The upper limit of the generalisation appears to be 80 lb. of nitrogen per acre at Tocklai, and less at the Dooars Sub-Station (Page 103). The response given by a pound of nitrogen is higher in Assam than at St. Coombs. The highest figure we have so far obtained is 4.8 lb. of tea for every pound of nitrogen and the average over the whole experiment is about 4. At Tocklai the highest figure is double this. Here then is an example where the general principle is the same and the detailed operation of the principle different in the two regions.

In regard also to the perennial question of the use of inorganic nitrogen, particularly sulphate of ammonia, Mr. Cooper demonstrates that in the early years of the experiment sulphate of ammonia equalled any other source of nitrogen in crop response, but that from 1924 it has produced significantly greater crops. (Page 24). He ascribes this to the slow but progressive increase in soil acidity that sulphate of ammonia causes. (The general run of pH values in Assam is higher, *i.e.* more towards the alkaline side of the scale, than those in Ceylon). Whether on soils usually more acid from the start we shall find our yields follow the same course remains to be seen. Mr Cooper's findings on rate of availability of organic manures correspond with ours. "It will be observed also that the animal meal (or concentrated organic manure commonly presumed to be slow acting) is fully as rapid in action as sulphate of ammonia, just as blood meal and horn meal are at Borbhetta." (Page 125).

Quality.—After considering various kinds of nitrogenous manures including inorganic and organic artificials and cattle manure, the

memorandum sums up the findings in these words: "Although differences in quality due to manuring are so small that it is difficult to prove them significantly great, the results obtained always indicate drops in quality with increased crop, but quality shows no relationship with the form of nitrogen used." The quantity of nitrogen required to show up a quality effect is 80 lb. (in comparison with 40 lb. or nil). Our results have not yet given a consistent difference even with 80 lb. though they may well do so when the successive doses of 80 lb. have brought the bush yield to a ceiling. Then, as Sir John Russell indicated at the last Conference, is the time to expect quality effects of recognisable dimensions.

Relation of Manuring to Pruning.—Mr. Cooper fully upholds our experimental conclusions regarding the relationship between the pruning operation and manuring. It must be remembered that annual pruning in Assam is very light, similar to our cut-across. A reference to Plate 5A in Tea Research Institute Bulletin No. 14 will give a reasonable idea of typical Assam pruning. Recovery from this is rapid. But every 10 or 15 years it becomes necessary to prune back bushes severely in order to prevent them from becoming too high. This "medium pruning" (to distinguish it from the normal operation on the one hand and collar pruning on the other) is similar to our clean pruning. Speaking of such pruning the memorandum says, "In 1933 the tea, which had become very high, was cut back to 18 inches from the ground. In that year no manure was applied, it having been shown on other plots that cut back tea carried too little leaf to make use of manures." (Page 26). Later, on a similar theme we have, "It is useless to manure a collar pruned bush. Even a medium pruned bush benefits little . . . . . It is quite safe to save money by omitting manuring in the year in which a section is cut back." (Page 72).

Green Manuring and Composting.—There are a number of references to the alternative use of green manure loppings and compost. As in our own case, Tocklai has established by parallel investigation the wasteful folly of composting green manures, including prunings. "For example, the leaves of *Boga medeloa* (*Tephrosia candida*) and indeed of most leguminous plants, contain so much nitrogen that they are readily available nitrogenous manures if hoed into the soil in a fresh, green state. If composted they lose nitrogen and become of less value" (Page 39). In one experiment at Tocklai *T. candida* cuttings were used as a manure. Observation and yield records of these plots showed that "the cuttings prove very rapid in action. There was never any trace of any 'poisoning' effect on the tea." Tocklai carried out the interesting experiment of using the raw materials of compost manufacture (including rice straw which

alone will not rot down) hoed into the soil direct in one case, and normally composted in the other. The results were equivalent (pages 50, 123).

The Effect of Weeds, Subsidiary Crops and Cultivation.—Mr. Cooper deals with this subject incidentally as interconnected with manuring and so does not display the relevant data which are, however, available in other publications. His summary reads: "All our trials at Borbhetta or Tulsipara indicate clearly that increase in cultivation, either in frequency or in depth, produces little or no effect beyond the point at which weeds are suppressed, but that any increase in the cover of weeds reduces tea crop. (Page 80). As in our case he is particularly insistent on the harmful effect of grass. (Page 84).

Time of Application.—The correspondence between the findings of the Tocklai Station and the Tea Research Institute is impressive and there is little divergence of opinion. One such apparent divergence needs detailed consideration. Discussing time of application of manure Mr. Cooper says: "Application later than June fails to give full effect in the season of application, but what is not then used increases crop in the next season" (Page 81). Later, the memorandum repeats this statement with the added suggestion that what is not used remains in the soil. (Page 91). This is contrary to our experience, but though we cannot speak with certainty on this matter we can, as Mr. Cooper occasionally does, make an intelligent guess as to the reason. In the first place if the manure lies dormant in the ground, in Assam it is doing so in a dry season with a minimum of loss due to seepage. But there is another possibility that cannot be rejected. The bush may *absorb* the bulk of the manurial dressing quite soon after its application and after elaboration store the nitrogen not used immediately for growth. Nitrogen unlike carbohydrate appears to be stored throughout the tissues of the bush. Under Assam conditions of light pruning little of this is sacrificed; under Ceylon conditions of clean pruning a large proportion goes into the fire as prunings. We should have to know much more about the physiological use of nitrogen in the bush before we could state with assurance anything more definite than this. This point is closely connected with another which Mr. Cooper words as follows: "We may say then that about three quarters of the effect of steady manuring at the same annual level, is due to dressings of the previous years, and only one quarter to the dressings of the current year." (Page 91). This may be interpreted in two ways: (1) that there is a residual portion of previous dressings in the soil having a belated effect, (ii) that the increase in size and vigour of a bush by reason of previous manuring makes

it a better forager for soil nitrogen, and that in this sense the effect of manuring is cumulative. This second interpretation is the correct one, and is borne out by Mr. Cooper's figures in the appendix. The return in immediate crop from manuring is approximately steady (what I have called the "nitrogen equivalent"); the subsidiary effect of continuous manuring is to raise the "residual equivalent."

Mr. Cooper's association with Tocklai is unfortunately drawing to a close. This memorandum is a distinguished contribution whereby his labours should be remembered with gratitude by all concerned with the culture of tea.

T. EDEN.

FURTHER TESTS WITH THE CLIVEMEARE ROLLER

ROLAND V. NORRIS D.Sc.

In *The Tea Quarterly*, 1938, Vol. XI, pp. 118-20 and 145-50 a report was given of certain experiments carried out by the Institute with the Clivemeare roller. Trade opinions on two experimental invoices sold in London, one of normal manufacture and the other using the Clivemeare machine, were also quoted.

Though certain differences of opinion in regard to the relative merits of these invoices were apparent, the London sale figures revealed a preference equivalent to approximately one penny per pound in favour of the Clivemeare teas.

In view of these results, obtained with teas made during the height of the South-West Monsoon, it was considered worth while to continue investigations of the process and, in particular, it was decided to forward two further comparative invoices made in the flavoury season for criticism and sale in London.

A more detailed account of the work carried out will be found in Bulletin No. 19, Annual Report for 1938, pp. 65-70.

The two further experimental invoices were manufactured on alternate days in February and March, 1939 in an exceptionally dry period. Invoice No. 2, sold under the mark "Coniston," was made by the Clivemeare process, while Invoice No. 3, sold under the mark "Newwood," represented normal St. Coombs manufacture.

The grading of each type of manufacture was as follows:—

	"Coniston" Clivemeare Manufacture	"Newwood" Normal Manufacture
B.O.P. ...	56	55
F.P. ...	13	12
O.P. ...	—	2
B.P. ...	—	9
P. ...	—	4
Fannings ...	21	12.5
Dust ...	6	3
Broken Mixed & loss	4	2.5
	100	100

B.O.P., F.P. and Fannings were alone sent for sale, samples of dust being, however, submitted for valuation.

The teas were sold in London on June 6th with the following results:—

	"Coniston" Clivemeare	"Newwood" Normal
B.O.P ...	1-7½	1-4½
F.P. ...	1-4½	1-4
Fannings ...	1-7¼	1-4¾
Average ...	1-7.1	1-4.4
Dust (Valuation) ...	1-3½	1-3¼

The Clivemeare teas therefore obtained a premium of rather more than 2½d per pound which would have been further increased if all grades had been submitted for sale.

Though the Clivemeare F.P. was reported as rather "ragged," the opinion in London was general that the appearance of the Clivemeare teas had been markedly improved since the experiments first began and were now such as to render them quite acceptable in the London market from this point of view.

Opinion was also unanimous in regard to the good colour and evenness of the Coniston infusions and the colour and strength of the liquors. This was particularly the case with the fannings.

In regard to the important question as to whether these desirable qualities had been obtained at the expense of any change or loss in flavour, there was not complete agreement. It was clear, however, that such loss, if any, was quite insufficient to offset the gain in other qualities. The following quotation from a report illustrates the position:—

> "In our opinion the Clivemeare invoice has lost a certain amount of actual Ceylon flavour and pungency, but has gained such richness in redness and roundness of liquor that it will probably be received by the Trade generally as the more useful invoice. This is especially noticeable in the case of the B.O.P. Fannings whose infused leaf is almost perfect in coppery evenness."

The position still remains somewhat obscure as to what amount of tea of the Clivemeare type could be absorbed by the market and whether a similar premium would be obtained if considerable quantities were available.

At the moment the following comments would seem to indicate the views of several members of the Trade:—

> "If the Clivemeare process is adopted on a large number of estates the position has to be envisaged when a considerable quantity of red, strong, up-country teas, previously found to be somewhat of a rarity and therefore a speciality so far as Ceylon is concerned, become a rule for Blenders rather than an exception. We think we have ground in saying and Messrs. — are in agreement, that up-country Ceylons are largely regarded by Blenders as a medium for giving 'life' and flavour to the duller, heavier teas from Northern India which form the large part of the 'filler' of at any rate the low and medium priced blends. At various times in the past, the light, pungent Ceylon teas have been in obvious request for this purpose. Blenders' requirements may be undergoing a long term change away from the light liquoring pungent teas, based on the belief that the public taste is showing a marked alteration towards drinking heavier and stronger types. Whether this is so, we naturally would not like to hazard a guess but, if it is intended to recommend the Clivemeare process for general use in Ceylon and this recommendation is extensively followed, the whole basis and type of Ceylon offerings would almost certainly be radically altered. Not only is there a possibility that the premium paid for a speciality might

easily be lost but the whole position of Ceylon quality might conceivably be endangered. We do not make these observations in any spirit of detraction from the value of Clivemeare teas that have just been sold. In fact their superiority in terms of price was so conclusive that we have not thought it necessary to pass on to you Buyers' views. We have however discussed the Sale and its implications with most of the leading selling Brokers in the Trade and their opinions are embodied in the letter. Although not all of them preferred the Coniston teas, they showed the greatest interest in the experiment and a considerable body of opinion favoured, as we do ourselves, the use of the Clivemeare roller in mid-country rather than up-country estates as being less likely to endanger Ceylon quality."

After careful consideration of the above and other comments, it was considered desirable to afford further opportunities for the London market to examine these teas and it was decided that six further invoices of Clivemeare manufacture should be made and sold in London.

One such invoice had been despatched when War broke out. In consequence of the Government control of the tea market which has now been imposed, it is clear that no evidence of value from the experimental view will be obtained from its sale and no useful purpose served by sending further such invoices to London.

For the present, therefore, experiments on the commercial scale have been suspended.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 13-7-39

Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon held in the Committee Room of the Ceylon Chamber of Commerce, Colombo, on Thursday, 13th July, 1939, at 2-30 p.m.

Present.—Mr. James Forbes (Chairman), the Director of Agriculture (Mr. E. Rodrigo, C.C.S.), the Acting Chairman, Planters' Association of Ceylon (Mr. C. W. M. Davies), the Chairman, Ceylon Estates Proprietary Association (Mr. C. H. Bois), Messrs I. L. Cameron, J. D. Hoare, J. C. Kelly, T. B. Panabokke, S. F. H. Perera, Gordon Pyper, and Dr. R. V. Norris (Director and Secretary). Dr. C. H. Gadd (Mycologist) also attended by invitation.

A letter was received from Major J. W. Oldfield regretting inability to attend.

1. The Notice calling the Meeting was read.

2. The Minutes of the Meeting of the Board held on 31st March, 1939, were confirmed.

3. MEMBERSHIP OF THE BOARD AND COMMITTEES

(i). *Board.*—Reported that Mr. C. H. Bois had become an ex-officio Member of the Board as from the 20th April, 1939, on his election to the Chairmanship of the Ceylon Estates Proprietary Association, *vice* Mr. R. J. Hartley (Letter dated 20th April from the Secretary, C. E. P. A.)

The Chairman welcomed Mr. Bois and also Mr. C. W. M. Davies, Acting Chairman, Planters' Association of Ceylon. A vote of thanks to Mr. R. J. Hartley for his services to the Institute was recorded.

(ii). *Estate and Experimental Sub-Committee.*—The Chairman referred to the fact that Mr. C. Huntley-Wilkinson, who had been a Member of this Committee since its inception and who had also served on the Board and as Chairman for a short period in 1929, was shortly retiring from Ceylon. Appreciative reference to his keen and valuable services had been made at the last Meeting of the Experimental Sub-Committee and he thought the Board would

similarly wish to record their grateful thanks to Mr. Wilkinson for all he had done to further the work of the Institute. This was agreed to with acclamation.

4. FINANCE

(i). The Accounts to 31st May were accepted.

(ii). *Additional Votes, Research.*—The Board approved of the following votes:—

Revenue Account. Vote 31.—Field Experiments, Plant Physiologist Rs. 600 being cost of importing varieties of tea seed for selection experiment.

Revenue Account. Vote 74.—Conference Expenses Rs. 327/-.

Capital Account.—Guest House Rs. 150/- to Colas approach road.

5. ST. COOMBS ESTATE

6. MINUTES OF THE EXPERIMENTAL AND ESTATE SUB-COMMITTEE MEETING HELD ON THE 8TH JULY, 1939

At the suggestion of the Chairman, the above two items were considered together.

The following votes, recommended by the Experimental and Estate Sub-Committee were approved:—

Estate Working Account.—Vote 33, Illuk & Cooch. Rs. 100 -
—Vote 34, Poria Control Rs. 100/-

Capital Account.
—Vote 73, Machinery Rs. 1,000/- for purchase and erection of a circular saw.

—Vote 81, Soil Erosion. Additional vote of Rs. 300/ for work on the clearings was approved in principle, to be finally sanctioned by Chairman if required.

Manufacture.—The Chairman called attention to the very interesting Report attached to the Minutes of the Experimental and Estate Sub-Committee on the recent sale of T. R. I. Clivemeare tea in London and invited the opinion of the Board on the recommendation of the Committee that as a *temporary* measure the whole of

St. Coombs crop should be manufactured by this process so that six further breaks could be sent for sale in London. These invoices would be sold under St. Coombs mark and a satisfactory indication should thus be obtained as to the market's opinion of this type of tea. If favourable results were obtained the requirements of the Colombo market would have to be considered and the general policy in regard to manufacture would come up for consideration. Meantime work would be carried out to see how far similar results could be obtained with conventional rollers.

In reply to Mr. Bois, the DIRECTOR said the two experimental invoices, Normal and Clivemeare, recently sold were made on alternate days.

MR. CAMERON asked if it was now intended to send comparative invoices of Normal and Clivemeare tea. To this the CHAIRMAN replied this would cause undue delay owing to the smallness of St. Coombs crop. Prices could, however, be compared with those obtained by other estates in the district working on normal lines.

MR. HOARE pointed out that it was uncertain what quantities of Clivemeare tea could be absorbed by the market. He assumed that the Institute in replying to enquiries as to Clivemeare manufacture would confine itself to giving details of the experimental results obtained and would not take the responsibility of advising estates as to the policy they would adopt in regard to the type of manufacture.

After further discussion the Board unanimously approved of the proposal that the next six breaks should be made by the Clivemeare process and sent for sale in London.

Green Manures and Shade.—Referring to the recommendation in regard to a greater use of Albizzia on St. Coombs, MR. PYPER asked if Gliricidias could not be grown. DR. GADD replied that the results with Gliricidia had been unsatisfactory, the elevation being probably too high. Albizzias on the other hand were doing very well.

The Board accepted the Visiting Agent's Report dated 27th May, 1939, and the Minutes of the Meeting of the Estate and Experimental Sub-Committee held on the 8th July, 1939.

7. DISEASES AND PESTS

Tortrix.—Reported that the regulations in regard to Tortrix made under the Plant Pest Ordinance have been suspended as requested by the Institute. The Chairman thanked the Director of Agriculture for his assistance in this matter.

8. T. R. I. CONFERENCES

THE CHAIRMAN said the Minutes of the last Board Meeting containing full details of the discussion on the suggested Liaison Committee, etc. had been sent to the Planters' Association of Ceylon and to all District Planters' Associations. The subject has been discussed by two or three districts.

The Planters' Association of Ceylon was in favour of the formation of such a Committee.

Nuwara Eliya District Planters' Association had already nominated two Members to serve on the Committee if formed.

Other District Planters' Associations had apparently not discussed this aspect of the question.

Kandy District Planters' Association favoured sectional conferences with adjacent districts, *e.g.*, a conference at Kandy for Kandy, Matale and Madulkelle planters.

Madulkelle suggested that intimation of staff visits should be sent to District Planters' Associations to enable other Superintendents to meet the officer in question.

The Board has instructed the Director and himself to put up concrete proposals and, after discussion of the matter, the following scheme was suggested, for consideration:—

(a) A Committee be formed consisting of:—

(1) 2 Representatives of the Planters' Association of Ceylon.

(2) 2 Representatives of the Ceylon Estates Proprietary Association.

(3) 2 Representatives of the Low-Country Products Association.

(4) 2 Representatives of each District Planters' Association interested in tea.

(5) 10 General Representatives, nominated by the Director to include Visiting Agents, Proprietors and unorganised interests.

(b) This Committee to meet at St. Coombs, its function being to keep all interests informed of the investigations in progress at St Coombs and at the same time bring to the notice of the Institute any problems of special interest to particular districts.

(c) In future *two* Visitor's Days per month to be arranged, namely the *second* and *last* Wednesdays in the month.

It was suggested that the Committee would at most meet not more than twice in the year, once in a conference year, unless some urgent matter of general interest required to be discussed.

If the above suggestion were adopted general conferences on the present lines would continue to take place each second year.

The Chairman said that he and the Director hoped while in Assam later this year to examine the working of a somewhat similar Committee which exists there and they might therefore have further proposals to make on their return.

Mr. Pyper thought discussions might be deferred until after the Chairman and Director had paid their visit to Assam.

The Chairman suggested that if these proposals were approved by the Board, they might be sent now to the Planters' Association of Ceylon and the Ceylon Estates Proprietary Association for consideration, in order to save time.

The Board approved the proposals and the Secretary was instructed to send these to the Planters' Association of Ceylon and the Ceylon Estates Proprietary Association for their consideration.

9. SENIOR SCIENTIFIC STAFF

Reported that Mr. Lamb rejoined for duty after home leave on the 1st July.

10. VISIT TO ASSAM BY THE CHAIRMAN AND DIRECTOR

The Chairman reported that the visit to Assam by himself and the Director would extend from 1st October to 10th November, allowing about 4 weeks in North-East India. They hoped to visit the Tocklai Laboratory and representative tea areas.

Votes for the visit had already been approved in the estimates for the year and the Chairman said his Directors had agreed that he should accompany the Director.

11. RESEARCH ON THE CHEMISTRY OF TEA

Reported that Dr. A. E. Bradfield had accepted the appointment of Research Chemist to the Joint Scheme. The Director had written to Dr. Lampitt to obtain further details of the programme of work,

12. ANY OTHER BUSINESS

(i) Reported that His Excellency the Governor had visited the Institute on the 1st May.

(ii) The Board approved the signing of the necessary agreement with the Postmaster-General in regard to the installation of the automatic telephone system.

The Meeting then concluded with a vote of thanks to the Chair.

ROLAND V. NORRIS,
Secretary.

NOTICES.

The Institute's Laboratories and Offices are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. M. Y. Hemachandra & Co., Forwarding Agents. Carriage should be pre-paid.

Visitor's Days.—The *second* and *last* Wednesdays in each month have now been set aside as Visitor's Days at St. Coombs Estate and also at the T. R. I. Sub-Station, Gonakelle Estate, Passara, when it is hoped anyone interested will visit the Stations.

Visitors at other times are welcomed, but it is requested that an appointment be made if possible.

RULES FOR THE OCCUPATION OF ST. COOMBS GUEST HOUSE

(1). The Guest House is normally intended for the use of persons visiting the Institute and St. Coombs Estate on business. Children can in no circumstances be accommodated.

(2). Permission to occupy a room for the night must be obtained from the Director in writing and, unless sufficient notice be given, accommodation cannot be guaranteed. Two double rooms are available for the use of visitors accompanied by their wives.

(3). All visitors must sign the Visitors' Book on arrival.

(4). A bedroom may not be occupied for more than one night if required by another visitor. This shall not apply to Members of the Board or of Committees meeting at St. Coombs who shall also be entitled to priority in the allocation of accommodation when on official business.

(5). Complaints or suggestions shall be entered in the book provided for the purpose and not made to the Guest House Staff.

(6). All payments due for services rendered shall be made in *cash* to the steward-in-charge and a receipt obtained from him on the official form. The scale of approved charges is posted in the building. The steward is forbidden to give credit or to accept cheques.

(7) Liquor is supplied for consumption *in the premises only*.

(8). The Institute accepts no responsibility for cash, jewellery or other valuables of any kind left in the Guest House.

(9) All breakages will be charged for at cost price.

ROLAND V. NORRIS,
Director.

The Tea Research Institute of Ceylon.

BOARD OF CONTROL

(A) Representing the Planters' Association of Ceylon :—

(1) Mr. R. G. Coombe (on leave) Mr. Gordon Pyper (acting).

(2) Mr. Jas. Forbes, (Chairman)

(3) Mr. J. D. Hoare

(B) Representing the Ceylon Estates Proprietary Association :—

(4) Major J. W. Oldfield, C.M.G., O.B.E., M.C.

(5) Mr. I. L. Cameron

(6) Mr. J. C. Kelly

(C) Representing the Low-Country Products' Association :—

(7) Mr. S. F. H. Perera

(D) Representing the Small-Holders :—

(8) Mr. T. B. Panabokke

(E) Ex-Officio Members :—

(9) The Hon. the Financial Secretary.

(10) The Director of Agriculture

(11) The Chairman, Planters' Association of Ceylon

(12) The Chairman, Ceylon Estates Proprietary Association

Secretary, Roland V. Norris, D.Sc., St. Coombs, Talawakelle.

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The publications of the Tea Research Institute will be sent, free of charge, to Superintendents of Ceylon tea estates, over 10 acres in extent, and to Estate Agencies dealing with Ceylon tea, if they register their names and addresses with the *Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle.*

Other persons can obtain the publications of the Institute on application to the Director, the subscription being Rupees fifteen per annum for persons resident in Ceylon or India, and £1-5-0 for those resident elsewhere. Single numbers of *The Tea Quarterly* can be obtained for Rs. 2-50 or 4*s*. In the case of Indian cheques four annas should be added to cover commission.